REMARKS

This Amendment is submitted in response to the Office Action mailed on October 3, 2005. Claims 1 - 23 are pending, and all stand rejected at present. Claims 24 and 25 are added.

Amendments to claims 10 and 21 have removed the bases for the Examiner's objection under 35 U.S.C. §112.

Support for the amendments to the pending claims, and for the added claims, can be found in the Specification, paragraph [0014], and Figure 2, as well as other locations.

SUMMARY OF RESPONSE

Applicant respectfully submits that the Examiner is making an error in interpreting Stridsberg. This error is sufficient to preclude the rejection of all claims.

The error lies treating three **adjacent** coils in Stridsberg as producing three **separate** "poles." However, in the motors art, a "pole" is generally defined as one member of a **pair** of North and South poles. The three coils in Stridsberg appear to produce three magnetic fields. However, they add vectorially to form a **single** field, having a **single** North and a **single** South pole.

From another point of view, when an adjacent pair of North-South poles swings past a coil during rotation, a complete sine wave is generated. This occurs when the two-pole rotor of Sketches 2 and 3, shown on pages 13 and 14 below, swings past a coil. Thus, the pair (or two poles) is treated as containing 360 (or 2 x PI) electrical degrees: the pair generates a complete sine wave in one revolution.

The situation can be viewed from a different perspective. If one plots the magnetic field existing along the circumference of the two-pole rotor, one again obtains a complete sine wave. Sketch 3 on page 14 below illustrates this.

Sketch 4 illustrates a four-pole system. If the rotor rotates past a coil, **two**

complete sine waves are obtained. If the magnetic field is plotted, as shown in Sketch 4, again two complete sine waves are obtained.

If you replace one magnet (or electromagnet) in the rotor by three adjacent magnets (electromagnets), as shown in Sketch 5 on page 17 below, right side, you do not change the number of sine waves resulting (1) from rotating past a coil or (2) in plotting the magnetic field. The three replacement magnets behave as a **single** magnet.

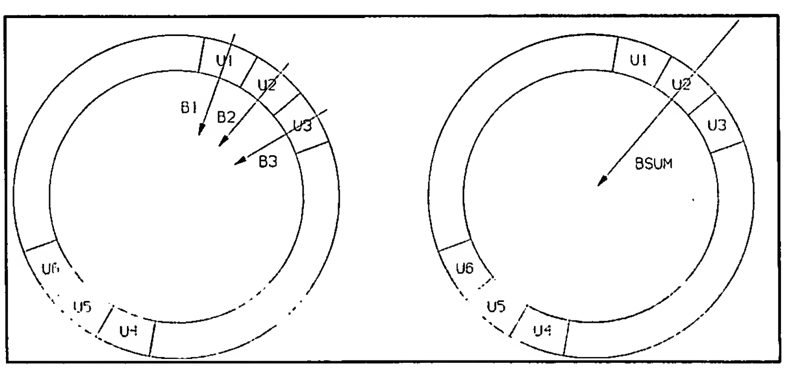
Thus, Stridsberg's coils because they are adjacent, they do not act as individual poles. They act as a single pole.

Therefore, this is the error which Applicant respectfully submits to be present: treating Stridsberg's three coils as three poles. They act as a **single** pole.

This will be explained in greater detail in the following explanation.

Explanation

The PTO relies on three coils in Stridsberg, namely, coils U1, U2, and U3 of Stridsberg's Figure 2. Sketch 1, below, is a partial rendition of that Figure, showing the magnetic fields produced by those coils.



1Sketch 1

Applicant points out that the coils are connected **in series**. (Column 4, line 21.) Also, the coils are **physically adjacent**. Therefore, the magnetic fields shown in Sketch 1 are always present together in both time and space. They add vectorially to a **single** resultant field, indicated at the right side of the Sketch 1 above.

That **single** resultant field has a **single** North pole and a **single** South pole (neither shown, but, by convention, the magnetic field vector points from North to South).

The mere fact that three **coils** are present does not indicate that three **poles** are present. APPENDIX A, discussed below, confirms this.

Moreover, the three coils in Stridsberg do not **behave** as three poles. APPENDIX B, discussed below, confirms this.

Appendix A

APPENDIX A, attached, is an excerpt from a textbook on motors. Figure 2.11(b) shows four groups of coils. Each group contains three coils. Each group will be called a "triplet."

Two of the triplets generate South poles, and two triplets generate North poles, as indicated, for a total of four poles. Consistent with this total of four poles, the legend of the Figure indicates that a four-pole system is shown.

Four poles are present despite the fact that **twelve** coils are present.

Therefore, it is clear that multiple coils can be present in a **single** pole. In Figure 2.11(b) of APPENDIX A, three coils are present in each pole.

Conversely, it is clear that the mere presence of multiple coils does not indicate the presence of multiple poles, contrary to the Examiner's interpretation of Stridsberg. Again, Figure 2.11(b) of APPENDIX A illustrates three coils generating a **single** pole.

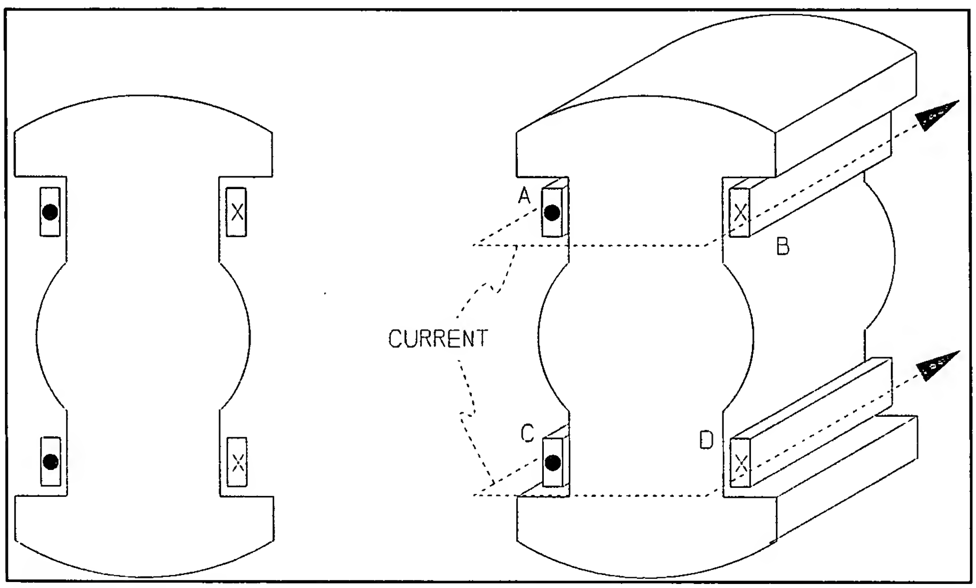
Appendix B

APPENDIX B, also attached, is another excerpt from a motors textbook. This discussion will summarize APPENDIX B, and will show that the Examiner's interpretation

of Stridsberg appears to violate a basic equation in the motor arts, or at least renders that equation meaningless.

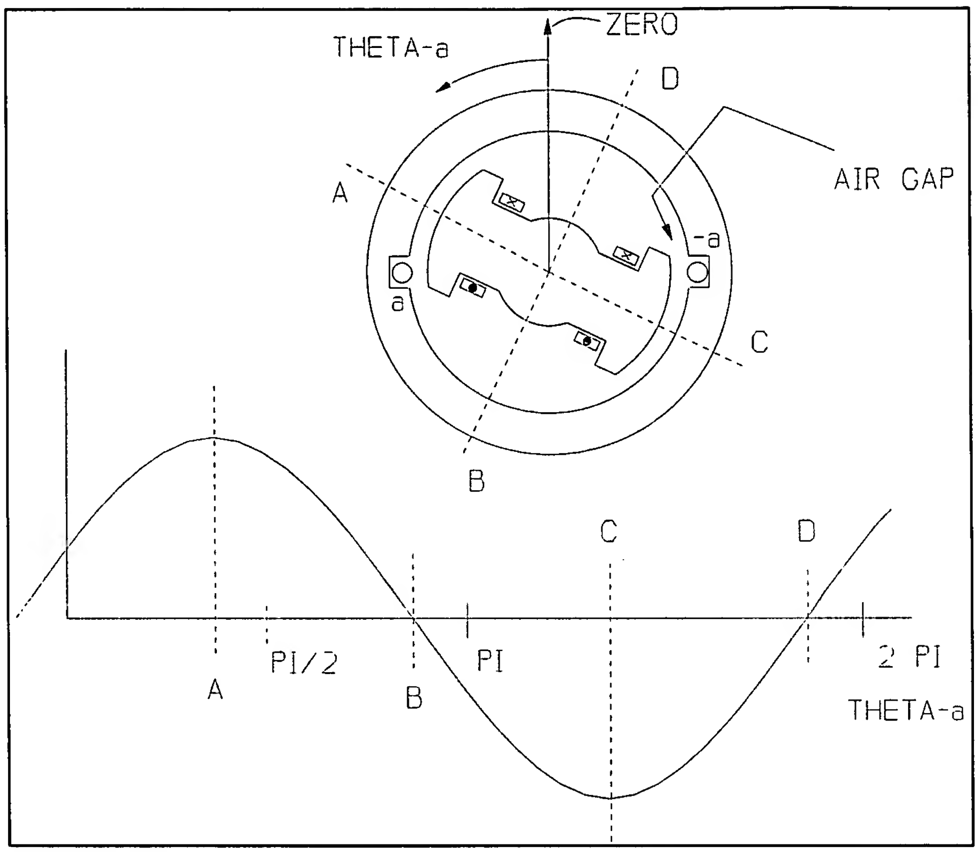
That equation is equation 4.1 in APPENDIX B. A brief background must first be given which explains the variables in that equation.

The right side of Sketch 2, below, illustrates the rotor of Figure 4.4 in APPENDIX B. The left side of the Sketch illustrates the rotor in cross-sectional view, as the rotor is shown in Figure 4.4



2**Sketch 2**

Sketch 3 below is a rendition of Figure 4.5(a) of APPENDIX B, together with Figure 4.4 of that APPENDIX superimposed on the Figure.



3Sketch 3

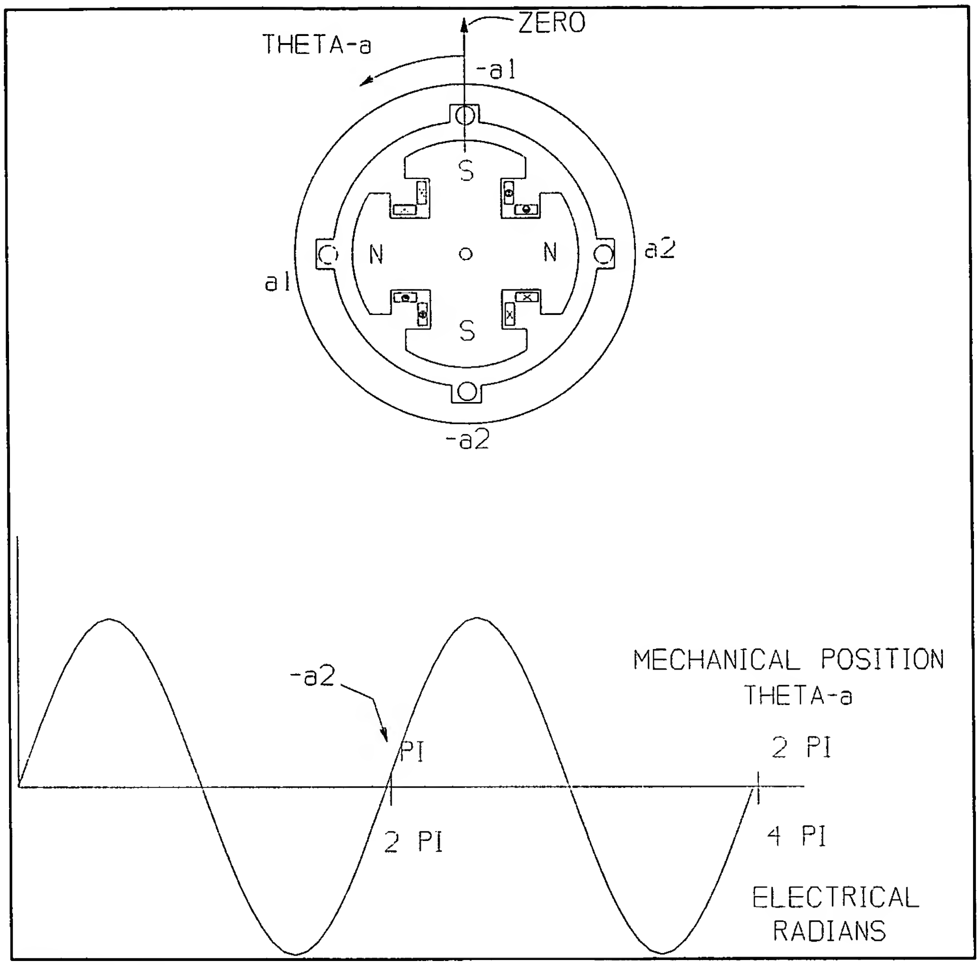
The plot of Sketch 3 shows the flux density within the air gap, plotted against angle. For example, the rotor as shown stands at an angle, THETA-a, of about 75 degrees, measured from the ZERO reference at 12 o'clock. That angle is labeled A on the rotor and also on the plot. Similarly, angles B, C, and D are also labeled.

Stator coil a would be at 90 degrees, and Stator coil -a would be at 270 degrees in the illustration.

The plot shows the magnitude and sign of the magnetic field as a function of angle.

The important point is that in the two-pole system, the flux distribution follows a **single** sine wave. The flux distribution spans 360 (or 2 x PI) electrical degrees, consistent with the length of a single sine wave.

Sketch 4 below shows a four-pole system.



4**Sketch 4**

The plot in Sketch 4 indicates that the flux distribution contains **two** sine waves. That is, one trip around the rotor covers two sine waves, or 720 electrical degrees. This is indicated on the lower part of the horizontal axis of the plot in Sketch 3. The upper part indicates the actual, mechanical position on the rotor.

To repeat: as the plot indicates, the system of Sketch 4 contains 720 electrical degrees within the 360 mechanical degrees.

Now the equation in question can be explained. The equation is Equation 4.1, and it states:

THETA(AE) = (Poles/2) x THETA(A),

wherein

THETA(AE) is the angle, electrical,

Poles is the total number of North and South poles combined, and

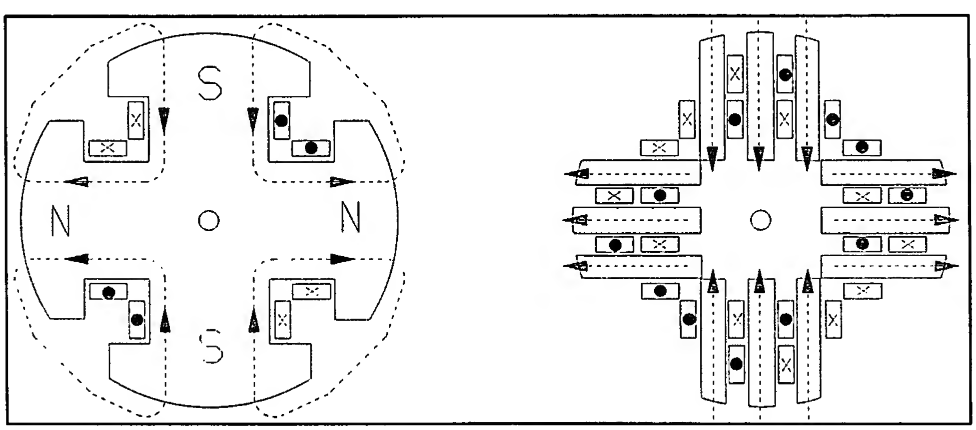
THETA(A) is the angle, mechanical.

If this equation is applied to Sketch 3, it is seen that the number of electrical degrees along the circumference of the rotor equals the number of mechanical degrees (360) because "poles/2" equals unity. That is consistent with the plot in the Sketch.

If this equation is applied to Sketch 4, it is seen that the number of electrical degrees equals twice the number of mechanical degrees (or 720), because "Poles/2" equals 2. That is consistent with the plot in the Sketch.

Now the inconsistency of the Office Action with this equation can be explained.

The left side of Sketch 5, below, is a rendition of the rotor of Sketch 4.



5**Sketch 5**

As understood, the Examiner, in essence, is arguing that, if each magnet in the rotor is replaced by **THREE** magnets (that is, three pieces of iron, each surrounded by a coil), as shown on the right side of Sketch 5, then each pole on the left side of Sketch 5 becomes converted into three poles.

That argument is plainly invalid. The modification does not change the number of poles. Three poles have not been created.

Stated another way, if either rotor in Sketch 5 rotates past a coil, the sequence is N-S-N-S in both cases. That is, four poles cross the coil per revolution. That sequence creates two sine waves.

Similarly, if one plots the magnetic field along the circumference of the rotor shown on the right side of Sketch 5, one obtains the same type of plot shown in Sketch 4.

Thus, each rotor in Sketch 5 represent 720 electrical degrees. The division of one magnet into three magnets, as on the right side, does not change this fact. The sequence during rotation is still N-S-N-S for a single revolution.

By way of further illustration, a coil wrapped around a slug of iron, as in Sketch 3. One set of poles (N and S) is present.

Now replace the slug of iron by laminated layers of transformer iron, as is commonly done in motors when an AC magnetic field is present. (The layers are parallel with the magnetic field.) If 10 layers are present, does that create 10 poles ?

No. The individual magnetic fields present in the layers behave collectively as a single magnetic field.

Conclusion

Therefore, the three coils U1, U2 and U3 of Stridsberg do not represent three poles. They are three coils in series which produce magnetic fields which collectively behave as a single field. Thus, the three coils produce a **single** pole.

Note on Terminology

The term "phase" can have several meanings. When one refers to "three-phase voltage," one generally means three sinusoidal voltages 120 degrees apart.

However, one can also refer to a coil, or set of coils, which is powered by one of those sinusoids. In this case, a "phase" refers to that coil, or set of coils. In this case, "phase" is largely synonymous with "pole."

RESPONSE TO REJECTION OF CLAIMS 18, 19, AND 21

These claims were rejected on grounds of anticipation, based on Stridsberg.

Claim 18

Applicant points out that claim 18 recites "(1) organizing said 6 poles into 2 groups of 3 poles each."

Stridsberg states (column 4, lines 18 - 20) that his "phase U" (for example) has six coils U1 - U6, which are divided into two groups, U1 - U3 and U4 - U6. Thus, six coils are present.

However, in electric motors generally, a "coil" does not correspond to a "pole." Stridsberg may show three **coils** in each group, but, again, each coil does not correspond to a "pole." This can be explained in several different ways.

Explanation 1

In Stridsberg's Figure 2, the group of coils U1 - U3 is diametrically opposite the group U4 - U6. They both produce a **single** magnetic field, along a diameter, which runs from U5 to U2 in the Figure.

In motor terminology, that magnetic field represents two poles, one North and one South.

If, because of the geometry of the system, the magnetic field of coils U1 - U3 does not reach coils U4 - U6, then each triplet of coils may form an independent field, having

two poles. That is, an N and S is associated with one triplet, and another N and S is associated with the other triplet.

Nevertheless, six poles are not present, as claimed.

Explanation 2

The coils in group U1 - U3 are connected in series, as are the coils in group U4 - U6. (Column 4, lines 20 - 21.)

Stridsberg's Figure 4 shows the excitation circuits. Coils U1 - U3, being in series, are treated as a single coil, and excited as such. This coil-group is powered, or excited, at any given time, in one of two ways.

-- Either transistors T13 and T16 are ON, with transistors T14 and T15 being OFF, causing current to flow through "U1-3" from left-to-right or, conversely,

-- transistors T13 and T16 are OFF, with transistors T14 and T15 being ON, causing current to flow through "U1-3" from right-to-left.

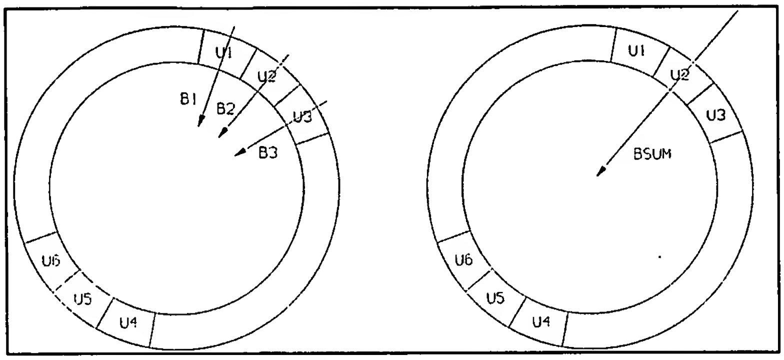
The other group "U4-6" in the Figure is powered the same way, but by transistors T7 - T10.

Thus, as shown in the left side of Sketch 1, below,

-- coil U1 produces magnetic field B1,

-- coil U2 produces magnetic field B2, and

-- coil U3 produced magnetic field B3.



6**Sketch 1 (Repeated)**

Those fields B1 - B2 add vectorially to produce the single resultant vector, labeled BSUM on the right side of the Sketch.

Coils U4 - U6 operate in a similar way, to produce their own BSUM. The two BSUMs add together, to form a **single magnetic field** (not shown).

That **single** magnetic field has two poles: one North and one South.

Therefore, Stridsberg's six coils U1 - U6 represent **two** poles.

Explanation 3

Stridsberg's Figure 2 shows six poles (column 4, lines 30 - 32):

-- U1 - U3,

-- U4 - U6,

-- V1 - V3,

-- V4 - V6,

-- W1 - W3, and

-- W4 - W6.

(Column 4, lines 27 - 29.)

He **explicitly** states that "group U4 - U6" is one "pole group" in the "six stator pole groups." (Column 4, lines 30 - 32.) He also states that "coils V4 - V6" form one pole, and "W1 - W3" form another pole. (Column 4, lines 30 - 34.)

Stridsberg states that each set of three coils forms a **single** pole. That is directly contrary to the PTO's interpretation.

Explanation 4

Stridsberg shows what is termed a "distributed pole" in the motor arts.

APPENDIX C, attached hereto, is taken from a motors textbook. Figure 4.20 shows windings of a single phase, similar to Stridsberg's. Even though **multiple coils** are present, as in Stridsberg, only a **single** magnetic field is created, having two poles (N and S).

Stridsberg shows a "distributed pole," in which **multiple** coils generate a **single** pole.

Conclusion

Stridsberg's six coils U1 - U6 form a single pole. (Possibly two poles, if the fields of one triplet do not reach the fields of the other.) In the motors art, this is called a "distributed pole."

Even though each of those six coils U1 - U6 individually produces its own magnetic field, those coils operate together as a **single group** (explaining Stridsberg's reference to them as a "phase" and a single "pole").

That "phase" produces a single magnetic field, having two poles (N and S).

Claim 18 recites **six** poles. Stridsberg does not show the claimed six poles.

Amendment to Claim

Claim 18 has been amended to state that each pole is separately excited. That is not shown in Stridsberg, nor can it be shown. His three coils U1 - U3 are in series, and must carry the same current. They cannot be separately excited.

In contrast, Applicant's Figure 2 shows that the coils 56 are separately excited.

As an aside, Applicant points out that three different voltages are applied to the three coils 56. In one embodiment, those three voltages take the form of three digitally

synthesized sine waves, of equal magnitude, but 120 degrees apart, because of the WYE-connection. This type of excitation is known in the art.

Claims 19 and 21

The discussion of claim 18 applies to claims 19 and 21.

RESPONSE TO REJECTION OF CLAIMS 1 - 10, 13 - 17, 20, 22, and 23

These claims were rejected as obvious, based on Stridsberg and O'Gorman.

General Response

The discussion above applies here. Under the invention, **an entire group of poles** is disabled in response to a fault in one of the poles. That is, the faulty pole is disabled, **plus other poles**.

That is not shown in Stridsberg. Stridsberg creates a **single** pole using multiple coils, by way of distributed windings. He disables all those coils at once, but that only disables a **single** pole.

Stridsberg does not disable multiple poles at once.

Applicant submits that additional reasons exist why the references do not show the claims, as will now be discussed.

Claims 1 and 2

<u>Point 1</u>

Applicant wishes to first explain the terminology of claim 1. Claim 1 recites:

> a stator including 2m poles . . . the improvement wherein said poles are organized into first and second m-phase groups

Assume that "m" equals three as in claim 2. This passage would then state a

stator including 6 poles . . . the improvement wherein said poles are organized into first and second 3-phase groups

Plainly, the coils U1 - U3 of Stridsberg do not show either a "first" or "second" 3-phase group as claimed. The coils U1 - U3 show a **single-phase group**. The primary reason is that coils U1 - U3 are connected in series, and must be powered together, that is, as a **single** phase. They are powered by a single phase.

Therefore, this claim recitation is not found in Stridsberg.

<u>Point 2</u>

Claim 1 also recites:

means for disabling all of said poles within the m-phase group of a shorted pole which has been so detected.

The Office Action relies on Stridsberg, column 2, lines 57 - 65 to show this. However, that passage merely states that "phases" or "winding groups" are disconnected. But he previously stated:

The coils of each phase winding are divided into winding groups . . .

The switching network . . . for each winding group comprises four power switches arranged in an H-configuration.

(Column 2, lines 25 - 30.)

His Figure 3 shows a "winding group," labeled "U1-3." (Column 4, lines 17 - 20 and 58.) That Figure also shows the four "power switches," in the form of transistors T13

- T16.

Stridsberg states that those four transistors are shut off, when a certain fault is detected. (See column 7, lines 31 - 44, where he discusses shutting down transistors T9 - T12.)

Therefore, Stridsberg only disconnects a **single** pole (or phase) upon malfunction. Claim 1 recites disconnecting **"all of said poles** within the m-phase group of a shorted pole." Thus, the claim recites disconnecting "m" phases. Stridsberg does not show that.

Claims 3 and 13

Claim 3 states that the poles are wye-connected. Figure 2 of Applicant's Specification provides an example.

Stridsberg shows something else. He states that his coils U1 - U3 are connected in series. (Column 4, line 21.)

The Office Action relies on his statement in column 10, lines 7 - 11. However, that does not apply to coils U1- U3. It applies to the poles U, V, W.

But those are not the poles which are disconnected as recited in claim 1. The interpretation of claim 3 is contrary to the interpretation of claim 1. The "poles" of claim 3 must be the same "poles" in parent claim 1. That has not been shown.

This applies to claim 13.

Claims 4, 8, 9, and 10

These claims are considered patentable, based on their parents.

Claim 5

Claim 5 recites six poles, separated by 60-degree intervals.

The Office Action relies on Stridsberg's Figure 10 to show this. However, Stridsberg's Figure 10 is ambiguous.

One interpretation is that the Figure contains nine poles: U-V-W-U-V-W-U-V-W. If

so, They are separated by 40 degrees, not sixty degrees as claimed.

Another interpretation is that the individual teeth each forms a "pole." (This interpretation is believed to be incorrect, as explained above.) But, even under this incorrect interpretation, 18 teeth are present. They are separated by 20 degrees, not sixty degrees as claimed.

Another interpretation is that one of the U's may be treated as a "pole," and the next "U" (separated from the first by one or more V's and W's) may be treated as another "pole." However, these two U's are separated by 5 teeth, or 100 degrees. That is not sixty degrees, as claimed.

Another interpretation is that each U refers to three teeth (that labeled "U," with the two flanking neighbors). In this case, three teeth would separate those triplets. However, such an interpretation is inconsistent. That interpretation means that the W's and the V's include only one, or two, teeth each, and that the W's and the V's include unequal numbers of teeth.

Therefore, no matter how Stridsberg's Figure 10 is interpreted, the claimed sixty degrees is not found.

Claims 6 and 16

Claim 6 recites:

> [the stator] provided with eighteen radially extending spokes, circularly positioned at regular 20 degree intervals, said poles being wound on every third one of said spokes.

The Office Action relies on Stridsberg's Figure 2. However, the individual teeth are not located at 20-degree stations. That Figure shows six "unwound" teeth, such as that between W6 and U1. (Column 4, line 33.) Thus, the angle between individual teeth is

less than 20 degrees.

Restated, Figure 2 shows 24 teeth, not the 18 teeth claimed, separated by 20 degrees.

Further, claim 6 recites:

said poles being wound on every third one of said spokes.

In rejecting parent claim 1, the Office Action relies on coils U1 - U3 to show three "poles." Those coils are wound on **adjacent** teeth. That is contrary to claim 6, which recites "every third one".

This applies to claim 16.

Claims 7 and 17

The interpretation of claim 7 is contradictory to the interpretation of claim 1.

Under claim 1, either the "first m-phase group" or the "second m-phase group" of claim 7 is disconnected upon detection of a fault.

The Office Action asserts that

-- the collected U's, V's, and W's on the **RIGHT** of Stridsberg's Figure 2 show the "first m-phase group,"

and

-- the collected U's, V's, and W's on the **LEFT** of Stridsberg's Figure 2 show the "second m-phase group."

However, at no location does Stridsberg state that **all** the U's, V's, and W's, on the right or left, are disconnected when a **single** fault is detected.

The PTO is now interpreting Stridsberg contrary to the interpretation used to reject parent claim 1. That is not allowed.

This applies to claim 17.

Claims 14, 15, 20, 22, and 23

These claims are considered patentable, based on their parents.

re: Combination of References

Point 1

No teaching has been provided for combining the references. A teaching is required.

A rationale was given for combining Stridsberg with O'Gorman in connection with claim 1. That rationale is that the combination of references provides O'Gorman with Stridsberg's "system for controlling rotational movement which is highly reliable."

However, Applicant points out that Stridsberg's title is "High Reliability Motor System." Thus, the PTO's rationale, in essence, asserts that the combination of Stridsberg with O'Gorman provides O'Gorman with the features of Stridsberg.

That is not a rationale which is allowed under section 103. That rationale merely points out supposed features of the combination, once made. But that rationale does not provide a teaching for making the combination in the first place.

Further, this rationale merely states that the combination of references provides the benefits of the two references which were combined. If that type of rationale is allowed, then the requirement of a teaching for combining references becomes meaningless. Any pair of references could be combined on that basis.

That is, **every** pair of references provides the benefits of the references which were combined.

Point 2

No rationale has been given for combining the references to produce the other claims in this group.

The Office Action apparently assumes that, once the references are combined for one claim, then dependent claims automatically become rejected, if the subject matter of the dependent claims is found in either reference.

That assumption is incorrect. Under the language of section 103, each claim **as a whole** must be shown to be "obvious." That is different than showing that the subject matter of each claim is merely found in the references.

The Office Action must show a teaching for combining the elements of each reference into each claim.

RESPONSE TO REJECTION OF CLAIMS 11 AND 12

These claims were rejected as obvious, based on Stridsberg and Recker.

Claim 11

Claim 11 recites:

11. In a motor vehicle steering system having a manually operated steering wheel and direction control apparatus responsive to rotational movement of said steering wheel by causing a directional change of said motor vehicle, steering assistance apparatus comprising;

(a) first sensor for generating a first sensing signal indicative of torque being applied to said steering wheel;

(b) a second sensor for generating a second sensing signal indicative of a rotational position of said steering wheel;

(c) computing apparatus programmed to read said first and second sensing signals, and to generate torque assist command signals therefrom, said torque assist command signals being directed into two separate, m-phase, torque assist channels;

(d) a motor having a permanent magnet rotor and a wire wound stator; said stator being provided with 2 groups of m-phase wire wound poles, the poles in each of said pole groups being connected for receiving torque assist commands transmitted by one of said torque assist channels, and able to

generate the corresponding torques; and

(e) a short detector for appraising said computing apparatus concerning the existence of shorts in said stator, said computer being programmed to generate control signals which switch off current to the windings of all poles within any channel in which a short has been detected.

Even if References are Combined, Claim 11 is Not Attained

POINT 1

Claim 11(c) recites a "computing apparatus" which reads the torque and position signals, and generates "command signals" which are directed to "two" channels.

The Office Action cites Recker, column 5, lines 3 - 6, to show that. However, that passage only states that a controller 60 "sends and receives signals 69 to and from motor 65." The recited two channels have not been shown.

Further, the Office Action's interpretation of Recker is inconsistent with its later admission of what is absent from Recker. The Office Action, page 7, section (d) states that Recker lacks a motor having two groups of "m-phase wire wound poles," connected to the two channels.

If the connection to the "two channels" is admitted to be absent from Recker, then how can it be asserted that Recker shows those "two channels," as was done for claim 11(b) ? For what are those "two channels," supposedly present, used ?

In this connection, Applicant points out that Recker states that he uses a three-phase motor. (Column 3, line 15.) That motor needs **three** "channels."

POINT 2

Claim 11 states that "current to the windings of all poles within any channel in which a short has been detected" is terminated.

Two channels are recited. Thus, Stridsberg would be required to terminate current in at least two phases (U,V), (U,W), or (V,W) on the right side of his Figure 2 (for

example). At no location does he discuss that. He only terminates a single phase, such as that formed by U1, U2, and U3.

Motivation for Combining References is Contrary To Recker's Own Teachings

The motivation for combining the references is to allow the motor to deliver power, even when a short is present. (Office Action, page 7, second-to-last paragraph.)

That is directly contrary to Recker's teaching. Recker states that, if a fault occurs, then the motor is shut down, and the steering wheel is operated manually, with difficulty. (Column 7, lines 21 - 27.)

A teaching which is contrary to that of the references cannot be used.

Even Ignoring Contrary Teaching, Motivation for Combining References is Insufficient

The rationale given for combining the references, in essence, states that the combination of references provides the characteristics of both references.

As explained above, that is not a teaching under section 103.

MPEP § 706.02(j) states:

> Contents of a 35 U.S.C. 103 Rejection
>
> . . . After indicating that the rejection is under 35 U.S.C. 103, the examiner should set forth in the Office action:
>
> . . .

(C) the proposed modification of the applied reference(s) necessary to arrive at the claimed subject matter, and

(D) an explanation why one of ordinary skill in the art at the time the invention was made would have been motivated to make the proposed modification.

To establish a prima facie case of obviousness, three basic criteria must be met.

First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings.

Second, there must be a reasonable expectation of success.

Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.

The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure.

Applicant points out that the rejection fails to comply with this MPEP section. The motivation for the combination has not been shown in the prior art.

Claim 12

Claim 12 is considered patentable for the reasons set forth earlier relative to claim 11 from which it depends.

ADDED CLAIMS

Claims 24 and 25 recite terminating power to poles in addition to a pole which is malfunctioning, while maintaining power to the other set of poles. That is not shown in the applied references, even if combined, and Recker appears to teach against that.

Applicant requests that the rejections to the claims be reconsidered and withdrawn.

Applicant expresses thanks to the Examiner for the careful consideration given to this case.

ATTACHMENTS:

APPENDIX A - An Introduction to Electrical Machines and Transformers, George McPherson, page 47;

APPENDIX B - Electric Machinery, Fitzgerald, Kingsley, and Umans, pages 177 - 179; and

APPENDIX C - An Introduction to Electrical Machines and Transformers (Same text as APPENDIX A), pages 189, 190.

CONCLUSION

For all the foregoing reasons and in view of the amended claims as now presented, Applicant believes all claims as now pending are not anticipated by the references cited by the Examiner, and accordingly, they should be allowed.

Applicant is filing concurrently under separate cover a request for a one month extension of time and information disclosure to cite the aforementioned materials.

The Commissioner is hereby authorized to charge any additional fees under 37 C.F.R. 1.16 and 1.17 which may be required by this paper, or to credit any overpayment, to **Deposit Account No. 50-1287**. Applicants hereby provide a general request for any extension of time which may be required at any time during the prosecution of the application. The Commissioner is also authorized to charge any fees which have not been previously paid for by check and which are required during the prosecution of this application to **Deposit Account No. 50-1287**. (Should Deposit Account No. **50-1287** be deficient, please charge any further deficiencies to Deposit Account No. 10-0220).

Applicant invites the Examiner to contact the undersigned via telephone with any questions or comments regarding this case. **APPLICANT(S) RESPECTFULLY REQUEST AN INTERVIEW WITH THE EXAMINER IF THIS AMENDMENT DOES NOT PLACE THIS CASE IN CONDITION FOR ALLOWANCE.**

Reconsideration and favorable action are respectfully requested.

Respectfully submitted,

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AN INTRODUCTION TO ELECTRICAL MACHINES AND TRANSFORMERS

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APPENDIX "A"

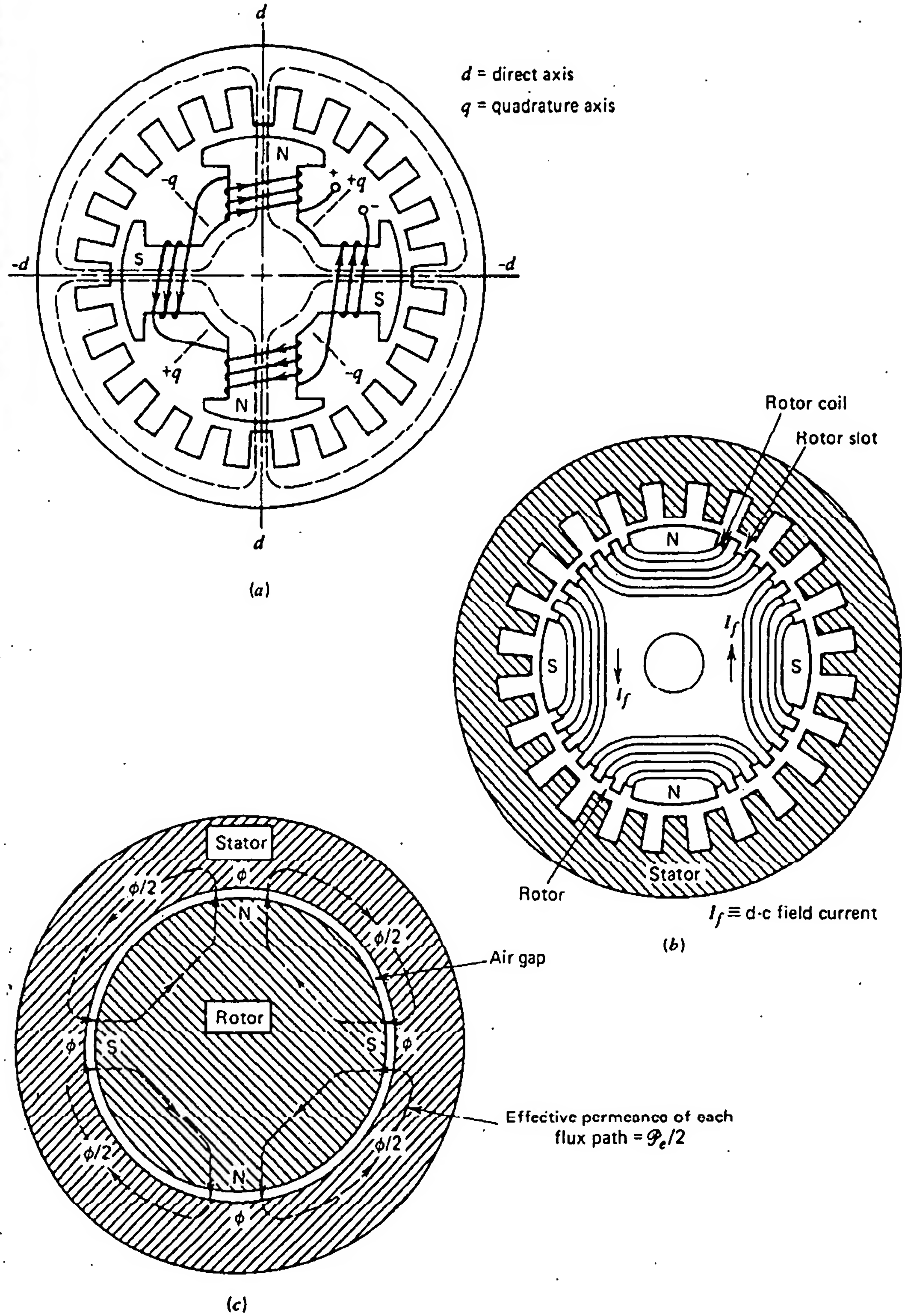

Figure 2.11 Magnetic geometry of synchronous machines. (*a*) Four-pole synchronous machine with salient-pole rotor. (*b*) Four-pole synchronous machine with cylindrical rotor having three coils per pole. (*c*) Magnetic geometry assumed for cylindrical rotor theory.

Electric Machinery

Sixth Edition

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APPENDIX "B"

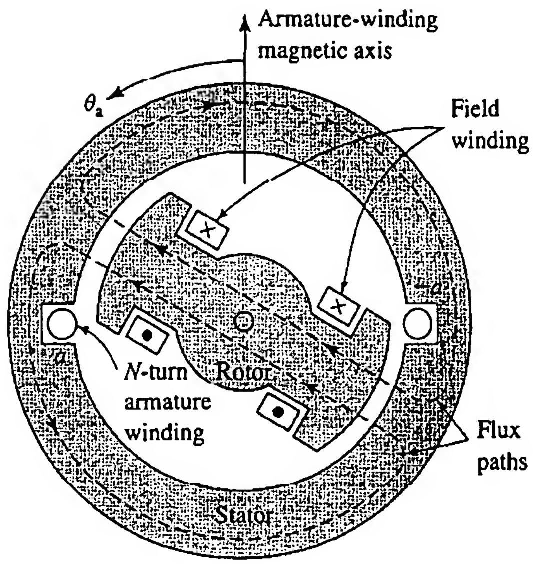

Figure 4.4 Schematic view of a simple, two-pole, single-phase synchronous generator.

to have the single, low-power field winding on the rotor while having the high-power, typically multiple-phase, armature winding on the stator.

The armature winding, consisting here of only a single coil of N turns, is indicated in cross section by the two coil sides a and $-a$ placed in diametrically opposite narrow slots on the inner periphery of the stator of Fig. 4.4. The conductors forming these coil sides are parallel to the shaft of the machine and are connected in series by end connections (not shown in the figure). The rotor is turned at a constant speed by a source of mechanical power connected to its shaft. The armature winding is assumed to be open-circuited and hence the flux in this machine is produced by the field winding alone. Flux paths are shown schematically by dashed lines in Fig. 4.4.

A highly idealized analysis of this machine would assume a sinusoidal distribution of magnetic flux in the air gap. The resultant radial distribution of air-gap flux density B is shown in Fig. 4.5a as a function of the spatial angle θ_a (measured with respect to the magnetic axis of the armature winding) around the rotor periphery. In

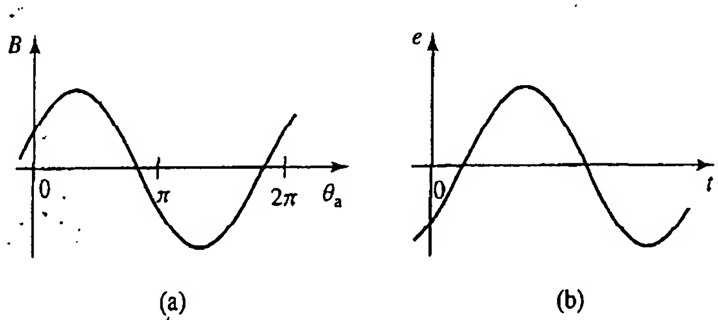

Figure 4.5 (a) Space distribution of flux density and (b) corresponding waveform of the generated voltage for the single-phase generator of Fig. 4.4.

practice, the air-gap flux-density of practical salient-pole machines can be made to approximate a sinusoidal distribution by properly shaping the pole faces.

As the rotor rotates, the flux-linkages of the armature winding change with time. Under the assumption of a sinusoidal flux distribution and constant rotor speed, the resulting coil voltage will be sinusoidal in time as shown in Fig. 4.5b. The coil voltage passes through a complete cycle for each revolution of the two-pole machine of Fig. 4.4. Its frequency in cycles per second (Hz) is the same as the speed of the rotor in revolutions per second: the electric frequency of the generated voltage is synchronized with the mechanical speed, and this is the reason for the designation "synchronous" machine. Thus a two-pole synchronous machine must revolve at 3600 revolutions per minute to produce a 60-Hz voltage.

A great many synchronous machines have more than two poles. As a specific example, Fig. 4.6 shows in schematic form a *four-pole* single-phase generator. The field coils are connected so that the poles are of alternate polarity. There are two complete wavelengths, or cycles, in the flux distribution around the periphery, as shown in Fig. 4.7. The armature winding now consists of two coils a_1, $-a_1$ and a_2, $-a_2$ connected in series by their end connections. The span of each coil is one wavelength of flux. The generated voltage now goes through two complete cycles per revolution of the rotor. The frequency in hertz will thus be twice the speed in revolutions per second.

When a machine has more than two poles, it is convenient to concentrate on a single pair of poles and to recognize that the electric, magnetic, and mechanical conditions associated with every other pole pair are repetitions of those for the pair under consideration. For this reason it is convenient to express angles in *electrical degrees* or *electrical radians* rather than in physical units. One pair of poles in a multipole machine or one cycle of flux distribution equals 360 electrical degrees or 2π electrical radians. Since there are poles/2 complete wavelengths, or cycles, in one

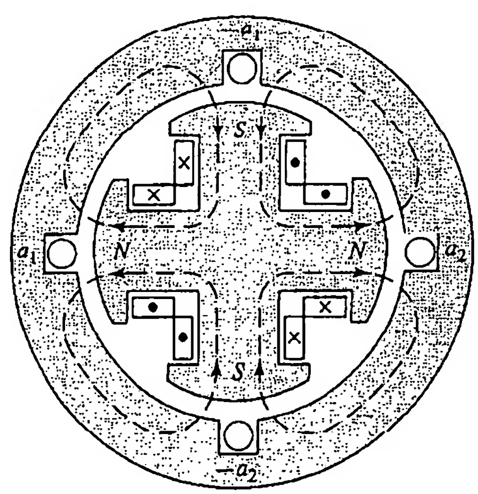

Figure 4.6 Schematic view of a simple, four-pole, single-phase synchronous generator.

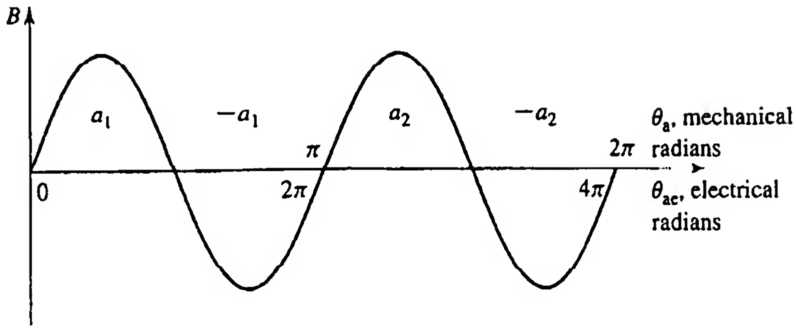

Figure 4.7 Space distribution of the air-gap flux density in a idealized, four-pole synchronous generator.

complete revolution, it follows, for example, that

$$\theta_{ae} = \left(\frac{\text{poles}}{2}\right)\theta_a \tag{4.1}$$

where θ_{ae} is the angle in electrical units and θ_a is the spatial angle. This same relationship applies to all angular measurements in a multipole machine; their values in electrical units will be equal to (poles/2) times their actual spatial values.

The coil voltage of a multipole machine passes through a complete cycle every time a pair of poles sweeps by, or (poles/2) times each revolution. The electrical frequency f_e of the voltage generated in a synchronous machine is therefore

$$f_e = \left(\frac{\text{poles}}{2}\right)\frac{n}{60} \quad \text{Hz} \tag{4.2}$$

where n is the mechanical speed in revolutions per minute, and hence $n/60$ is the speed in revolutions per second. The electrical frequency of the generated voltage in radians per second is $\omega_e = (\text{poles}/2)\,\omega_m$ where ω_m is the mechanical speed in radians per second.

The rotors shown in Figs. 4.4 and 4.6 have *salient*, or *projecting*, poles with *concentrated windings*. Figure 4.8 shows diagrammatically a *nonsalient-pole*, or *cylindrical*, rotor. The field winding is a two-pole *distributed winding;* the coil sides are distributed in multiple slots around the rotor periphery and arranged to produce an approximately sinusoidal distribution of radial air-gap flux.

The relationship between electrical frequency and rotor speed of Eq. 4.2 can serve as a basis for understanding why some synchronous generators have salient-pole rotor structures while others have cylindrical rotors. Most power systems in the world operate at frequencies of either 50 or 60 Hz. A salient-pole construction is characteristic of hydroelectric generators because hydraulic turbines operate at relatively low speeds, and hence a relatively large number of poles is required to produce the desired frequency; the salient-pole construction is better adapted mechanically to this situation. The rotor of a large hydroelectric generator is shown in Fig. 4.9. Steam turbines and gas turbines, however, operate best at relatively high speeds, and turbine-driven alternators or turbine generators are commonly two- or four-pole cylindrical-rotor

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APPENDIX "C"

$Ni/2$. On the assumption of narrow slot openings, the mmf jumps abruptly by Ni in crossing from one side to the other of a coil. This mmf distribution is discussed again in Section 4.4, where the resultant magnetic fields are evaluated.

4.3.1 AC Machines

Fourier analysis can show that the air-gap mmf produced by a single coil such as the full-pitch coil of Fig. 4.19 consists of a fundamental space-harmonic component as well as a series of higher-order harmonic components. In the design of ac machines, serious efforts are made to distribute the coils making up the windings so as to minimize the higher-order harmonic components and to produce an air-gap mmf wave which consists predominantly of the space-fundamental sinusoidal component. It is thus appropriate here to assume that this has been done and to focus our attention on the fundamental component.

The rectangular air-gap mmf wave of the concentrated two-pole, full-pitch coil of Fig. 4.19b can be resolved into a Fourier series comprising a fundamental component and a series of odd harmonics. The fundamental component $\mathcal{F}_{ag1}$ is

$$\mathcal{F}_{ag1} = \frac{4}{\pi}\left(\frac{Ni}{2}\right)\cos\theta_a \tag{4.3}$$

where θ_a is measured from the magnetic axis of the stator coil, as shown by the dashed sinusoid in Fig. 4.19b. It is a sinusoidal space wave of amplitude

$$(F_{ag1})_{peak} = \frac{4}{\pi}\left(\frac{Ni}{2}\right) \tag{4.4}$$

with its peak aligned with the magnetic axis of the coil.

Now consider a *distributed winding*, consisting of coils distributed in several slots. For example, Fig. 4.20a shows phase a of the armature winding of a somewhat simplified two-pole, three-phase ac machine. Phases b and c occupy the empty slots. The windings of the three phases are identical and are located with their magnetic axes 120 degrees apart. We direct our attention to the air-gap mmf of phase a alone, postponing the discussion of the effects of all three phases until Section 4.5. The winding is arranged in two layers, each full-pitch coil of N_c turns having one side in the top of a slot and the other coil side in the bottom of a slot a pole pitch away. In a practical machine, this two-layer arrangement simplifies the geometric problem of getting the end turns of the individual coils past each other.

Figure 4.20b shows one pole of this winding laid out flat. With the coils connected in series and hence carrying the same current, the mmf wave is a series of steps each of height $2N_c i_a$ (equal to the ampere-turns in the slot), where i_a is the winding current. The space-fundamental component is shown by the sinusoid. It can be seen that the distributed winding produces a closer approximation to a sinusoidal mmf wave than the concentrated coil of Fig. 4.19.

The amplitude of the fundamental-space-harmonic-component of the mmf wave of a distributed winding is less than the sum of the fundamental components of the

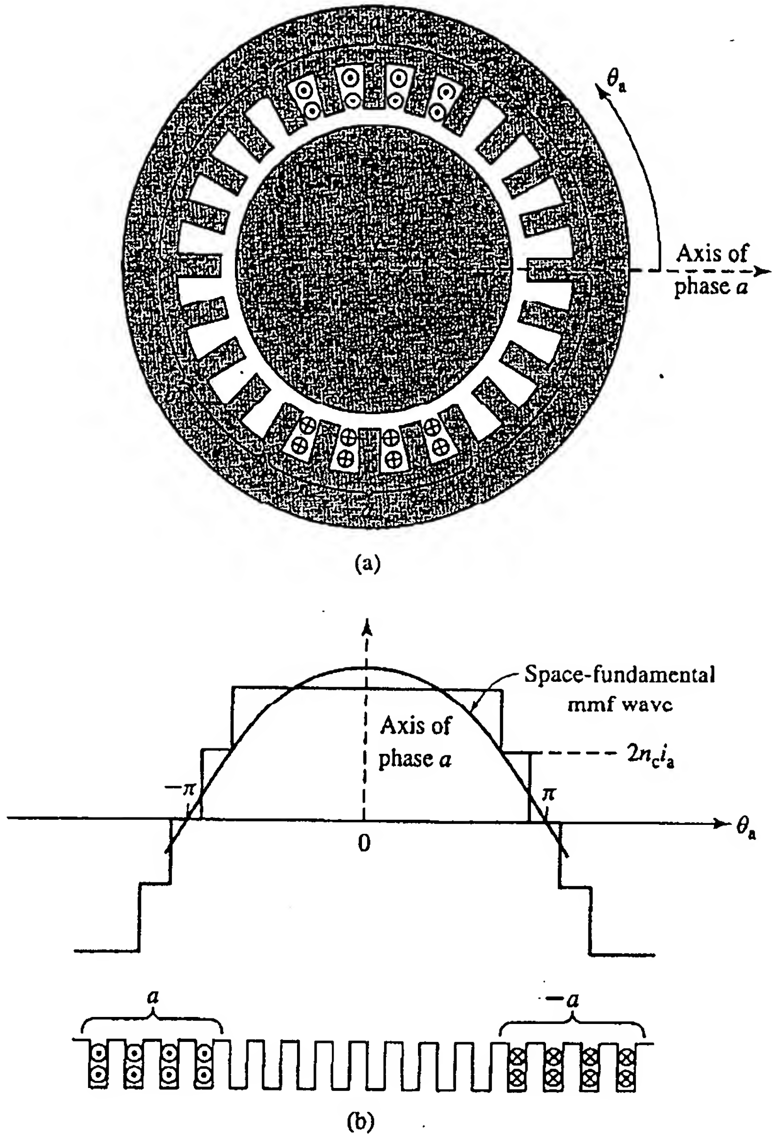

Figure 4.20 The mmf of one phase of a distributed two-pole, three-phase winding with full-pitch coils.

individual coils because the magnetic axes of the individual coils are not aligned with the resultant. The modified form of Eq. 4.3 for a distributed multipole winding having N_{ph} series turns per phase is

$$\mathcal{F}_{ag1} = \frac{4}{\pi}\left(\frac{k_w N_{ph}}{\text{poles}}\right) i_a \cos\left(\frac{\text{poles}}{2}\theta_a\right) \tag{4.5}$$

in which the factor $4/\pi$ arises from the Fourier-series analysis of the rectangular mmf wave of a concentrated full-pitch coil, as in Eq. 4.3, and the *winding factor* k_w takes into account the distribution of the winding. This factor is required because the mmf's produced by the individual coils of any one phase group have different magnetic axes.